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Summary:	The *MESH Guide to habitat mapping* aims to provide a methodological framework for marine habitat mapping so that future mapping studies will produce high quality data and maps which are inter-compatible and their outputs can be assimilated into common, harmonised maps. It will help to make habitat maps more compatible by illustrating tried and tested standards and procedures in a step-by-step manner. This document explains how data should be collected in accordance with a set of standard methodologies. The section provides practical advice on acquiring and recording data (*via* Recommended Operating Guidelines or ROGs), how to use techniques together and how to process data to suitable standards for analysis and interpretation.
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Close

How do I collect my data?

Jonathan White & Fiona Fitzpatrick

This section explains how data should be collected in accordance with a set of standard methodologies so that they can be compared with other data, collected at different times and by different survey operators. The section provides practical advice on acquiring and recording data (*via* Recommended Operating Guidelines ROGs), how to use techniques together and how to process data to suitable standards for analysis and interpretation. Having selected the required surveying methods and sampling needs it is then necessary to see how they can be best applied to survey areas, within the constraints of costs, time and available expertise.

Once the mapping target has been defined (using the 'Scoping Tool' from *What do I want to map?*), the next step is to select the required survey tools. The tools available for seabed habitat mapping are numerous: including acoustic techniques (echo sounders), benthic sampling techniques (grabs, corers, dredges and trawls), seafloor imaging (video and cameras) and remote sensing (satellites and aerial photography images). Many of these techniques are typically used in combination: for example using an echo sounding technique coupled with a grab sampling technique to "ground truth"; remote sensing technique coupled with a foot survey of a beach or intertidal area or; towing a video camera along the seafloor with an accompanying photographic "stills" camera, collecting higher resolution images to aid identification of animals/plants and seabed type.

This section aims to detail in a user friendly way, how and why different techniques, commonly utilised in marine habitat mapping are used (see *What do I want to map?* where the principles are explained), with their supporting requirements and how the data are recorded. Furthermore, the section explains the basic data processing and data cleaning giving clean, raw data sets ready for analysis and interpretation (see *How do I make a map?*).

The technique descriptions are support by case studies which detail actual surveys that have been undertaken, to give examples of the survey techniques in use, showing the type of survey they can be used for and the results that can be expected.

Organisation of the Section

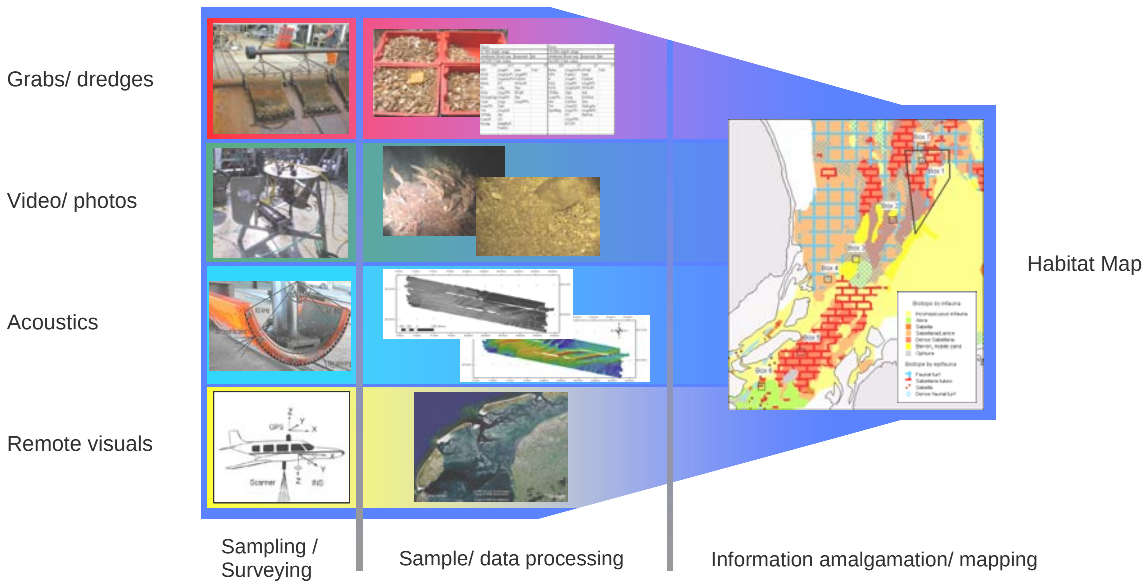
Techniques that are similar in their operation and data recovery are grouped and described together. The operation of techniques are detailed in individual Recommended Operating Guidelines (ROGs), which are grouped for remote sensing techniques, acoustic echosounder techniques, sampling and sediment analysis techniques, and underwater video and imaging techniques. Practical information on using techniques in combination is provided, followed by details of the metadata that need to be recorded. Finally this section outlines data cleaning and basic processing techniques, again for each of the survey technique groups. Accompanying these sections are case studies which provide examples of how the survey techniques have been employed and how the resulting data have been analysed for habitat mapping.

The ROGs can each be used as standalone summaries explaining the operation of the technique which they detail. Likewise, case studies are self contained reports, which summarise how techniques have been used in a practical seabed habitat mapping application.

Why do I collect mapping data in a standard way?

The method by which data are collected is integral to ensuring that the information they contain can be extracted and interpreted, and how these data are displayed on maps. The term "data" covers many forms of information, most usually we think of data as numbers, but it can include written descriptions, photographs, video footage, pictures and even physical samples. To ensure that data are of sufficient quality to be displayed or printed, in ways that can be understood, interpreted and compared with other types of information; sampling and surveying should be conducted in accordance with standard operating procedures (or Recommended Operating Guidelines).

For habitat mapping this usually means presenting the information on a map – putting it in a space and a time framework where it can be compared to other information of a different age. To do this we can use an array of surveying and sampling technologies and techniques. Some are simple to operate and some are very complex. However, they can be used in different ways and what makes the resulting data useful is the way they are used. If this is standardised, then the resulting data can be compared with confidence. This section covers the array and – operation of sampling and surveying techniques.



Data from surveys and samples through processing to plotting on charts.

If techniques are not used in an appropriate way, the information they collect may not be suitable for their intended purpose. To prevent this, techniques need to be used in predetermined, appropriate ways, even simple tools like a small dredge used over the side of a boat in shallow water to check seafloor material, if used in an organised way – in accordance with a predetermined set of rules – can be a powerful benthic habitat surveying instrument.

Technical expertise required for undertaking surveys

Such a large array of techniques requires mappers to have an understanding of many facets of marine technology, survey techniques and science. Essential is an understanding of marine biology and geology: taxonomy, assemblage compositions of different communities, seafloor materials and a grasp of the relative spatial extents that are to be expected of the target habitats. In addition to this, a good understanding is necessary of "seagoing activities", from the mechanics of how a large grab sampler actually works in collecting a sample of the seafloor, to how it will be deployed over the side of a boat or ship. This can be contrasted to the knowledge needed of the remote technologies often used for habitat mapping – for example the physics involved in echosounders should be understood, to a rudimentary degree at least, in order to appreciate the details of the resulting sounding maps.

Deck operations – deployment of a Box Corer.

This section details the knowledge that is necessary for data collection, which must be accompanied by detailed records of where and how data were acquired – metadata – and then the analysis of data requires a thorough understanding of data cleaning/quality control, integration and application of statistical analysis.

Many of the elements of data collection and processing are specific to individual techniques, while others are applicable to certain technique sets. Such a broad spectrum of techniques makes it sensible to document as much as possible, in as detailed a way as possible (while aiming not to overwhelm the reader), the information that is necessary for the successful application of each technique for the purpose of habitat mapping.

Recommended Operating Guidelines (ROGs) for habitat mapping

Most of the techniques used by habitat mappers were designed for other survey disciplines, most of which have well established standard operating procedures (SOPs) to provide quality data for their intended purpose. MESH at its outset undertook a Review of Standards and Protocols for Habitat Mapping (Coggan *et al.,* 2007) (available from the resource folder as MESH_Standards_&_Protocols_2nd Edition_26-2-07.pdf) with the aim of reviewing of existing material. It became apparent, that various organisations and institutions were utilising the same equipment in slightly different ways. One of the main reasons for this divergence has been user's translation of application of a technique from its originally intended purpose to habitat mapping. As a result, the MESH Recommended Operating Guidelines (ROG) were identified as necessary to describe how best to use each technique in a marine habitat mapping context. Where applicable, standard operating procedures, ISO-standards or similar are well known and recognised, references and links are made.

Recommended Operating Guidelines or ROGs are not intended to be prescriptive as the range of conditions, situations and environments in which techniques are used will necessitate adaptation to suit local needs. They reflect operational experience of using particular techniques for marine habitat mapping and ensure that the data required and obtained for habitat mapping are of a suitable quality and compatible with similar data from other surveys. It is important to adopt a certain level of consistency in the operation of a technique. Additionally, as many of the techniques can be used for purposes other than habitat mapping, it is important to indicate the particular way in which they should (or should not) be used for habitat mapping studies.

Links to resources

MESH_Standards_&_Protocols_2nd Edition_26-2-07.pdf

Structure of a ROG and considerations

ROGs have been written to describe how a technique should be used for habitat mapping, the general process of use, and to identify problem areas that could be encountered; so enabling contingency plans to be made. In addition and where not documented in ROGs, the following details (where appropriate) should be considered prior to use:

- Pre-installation checks, including power and space requirements, including loading requirements of the equipment onto a vessel (weight check, transport methods, deployment systems).
- Temperature ratings (if applicable).
- Mobilisation protocols and vessel storage requirements.
- Test and verification protocols including calibrations, an idea of how long this should take and any specialist equipment that might be required to undertake the calibration.
- How to best use the equipment.

- Quality Control procedures – detail of the best way to check that data are reliable and will give the required results. What should be checked and how frequently.
- Data storage & backup recommendations, (*e.g.* does the sample have to be chilled or frozen, do data need three backups).
- Data space requirements, (*e.g.* Sidescan sonar data require approximately four times the storage space needed by sub bottom profiler data, while a three day multibeam survey will generate in the order of a terabyte of data).
- Recommended logging information (this information should also be recorded in metadata, though it should also be possible to record situation specific information as free form comments (*e.g.* "a 3 degree list to port developed during the day, which will affect echo sounders – needs following up"; "winch line was changed, check positioning of towed frame as possibly effects on the angle the instrument was towed in the water and/or contact with the seafloor).
- Demobilization notes – how to repack the equipment (*e.g.* does power in the equipment have to be discharged, batteries removed or equipment washed with freshwater).
- Training – some equipment may require personnel to be specifically trained (*e.g.* ROV piloting, setting up of SPI (sediment profile imaging) equipment, processing grab and trawl samples).
- Safety precautions – such as transporting hazardous substances (*e.g.* Formalin); reference to national Health and Safety regulations (for instance in the UK "COSHH" – Control of Substances Hazardous to Health) and Risk Assessments.

Remote sensing techniques

Remote sensing techniques constitute an extremely sophisticated set of surveying approaches. Fully georeferenced images using visible and non-visible radiation are frequently gathered from airborne and satellite devices for the purpose of seabed habitat mapping. These are generally applicable in tidal and shallow areas with good water clarity. Electromagnetic radiation is readily absorbed by water, the degree of penetration depending on clarity, with typically clear water penetration being 15 to 20m.

These techniques are reliant on specialist operations, be they satellite or airborne. To this end, the ROGs for remote sensing techniques detail the operational data sources and available instruments, the technology of the techniques and how they may be used. The ROGs do not generally deal with specifics of deployment of these technologies, as this tends to be beyond the scope of organisations developing habitat maps. Surveys are commissioned of specific areas (in the case of airborne and LiDAR surveys), or in the case of satellite techniques, data are acquired from technically competent organisations operating the systems who will deal with operational technicalities.

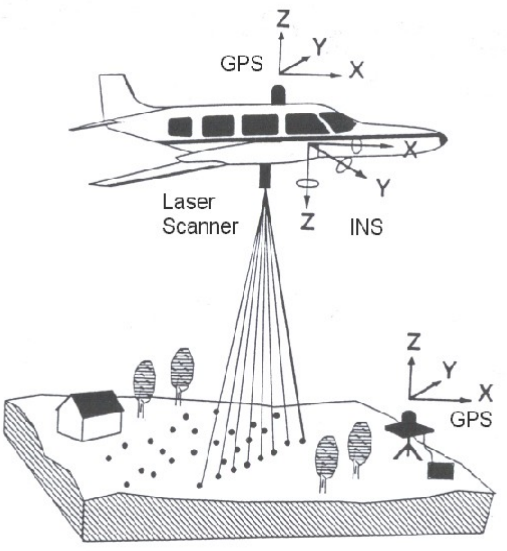


Illustration of LiDAR operation.

Aerial photography

The simplest form of remote sensing is aerial photography, involving georeferenced photographs typically collected from aeroplane or helicopter. Such platforms enable high rates of acquisition and 100% coverage. The approach is useful for mapping tidal areas and shallow, clear waters where seafloor features are visible.

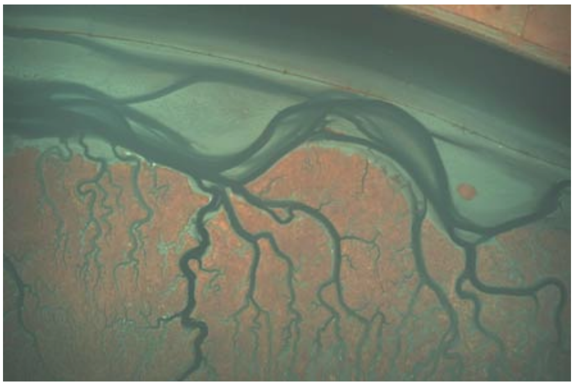
A photograph of clear shallow water with visible kelp, boulder and gravel– a suitable area for an aerial photographic survey.

Links to resources

[Aerial photography ROG.doc]

Airborne digital imagery

Electro-optical devices include high resolution multispectral and hyperspectral sensors for which sections of the electromagnetic spectrum, usually subsections of visible and near infrared portions of the spectrum (400 - 900 nm) are utilised in line with attributes of absorption of certain chlorophyll, algae and penetration of the water column. These have advantages over photographic surveys in that the different wave lengths can reliably provide data on the types of vegetation and substratum coverage. As with other airborne systems, rate of coverage is high as sensors are mounted on aeroplane or helicopter.



Infrared image of estuarine drainage patterns taken with a helicopter mounted camera.

Link to resources

[Airborne digital imagery ROG.doc]

Satellite imagery

Data layers from satellite sensors cover large expanses very quickly. Satellite mounted sensors use various parts of the electromagnetic spectrum, and so have limitations on depth of seafloor they can assess. The operating nature of satellites means they are rarely steered by marine benthic habitat mappers, with data requested from the operator and information supplier. Results are often from time periods that cannot be truly controlled owing to time of overpass and cloud cover. This can result in temporal composite images being supplied. Coverage can however, be of good quality and freely available – for instance from Google Earth.

Google earth imagery of south Dublin Bay showing structure of intertidal sand flats.

Link to resources

[Satellite Imagery ROG.doc]

LiDAR

LiDAR (*Li*ght *D*etecting *a*nd *R*anging) offers a very time efficient approach to surveying the bathymetry of shallow, intertidal and sub-tidal habitats and is particularly efficient for complex coastlines. Aeroplane-mounted lasers determine the difference in distance between the waters surface and seafloor, with accurate positioning of the aeroplane, determining its height and location. Whilst primarily a topographic technique, recent developments have show useful results in using the strength of the returning signal to determine the roughness and hardness of the seafloor, similar to echosounder backscatter, which can be used as a proxy for seabed structure/habitat.

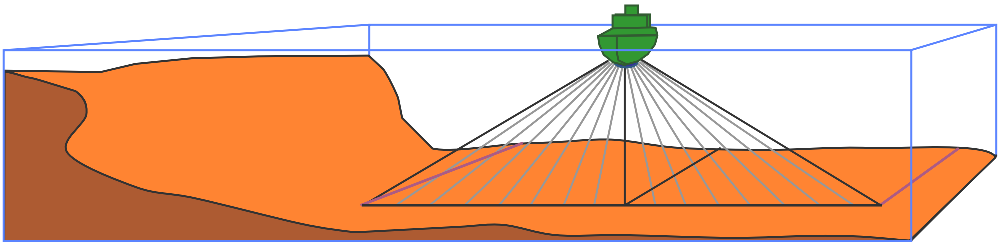
Links to resources

LiDAR ROG.doc

Case Study: Mapping seabed substrata using Lidar remote sensing WE_Ifremer_lidar.pdf

Acoustic techniques

Acoustic techniques are devices which emit sound energy, in a series of continuous pulses, into the water column and then detect the returning echoes. Different strengths of the echoes are then used to determine the morphology of features and physical characteristics/properties of the seafloor. By knowing the speed at which sound travels through water, depth can be calculated from the echo return time. This can be an extremely accurate measurement, which when coupled with accurate positioning systems and motion sensors can be used to produce very accurate seafloor maps. Similarly by knowing the speed of sound within a stratigraphic unit *e.g.* surface sediments, the thickness of the unit can be determined.



Schematic of the mode of operation of swath acoustic techniques

The systems can be sub-categorised into single beam and “swath” depth sounders, and sub bottom profilers:

Single beam echo sounder

Single beam echosounders use one emitting and receiving “transducer”, which releases a series of energy pulses in the form of sound waves, “ensonifying” (filling with sound) a small area underneath the boat. The time lag between the sound being emitted and its returning echo is used to calculate water depth beneath the boat.

Link to resources

Single beam echo sounder ROG.doc

Single beam echo sounder and ADGS

The signal reception of a single beam echosounder can be used to infer and classify seafloor habitats. These work in a variety of ways – and the user is directed to the relevant manufacturers’ manuals – for instance (and in brief) RoxAnn™ and ECHOplus utilise the time lag between the return of the first signal received and a second, weaker signal owing to sea surface reflection, to describe features of the seafloor. The distribution pattern of points produced when echo 1 (E1) and echo 2 (E2) are plotted against one another, when coupled with detailed ground truthing, can be used to classify the nature of the seafloor. Other software may only use the first echo, for instance that of Quester Tangents “Impact”

(http://www.questertangent.com/pdfs/QTC_Impact_04_Hi.pdf).

Links to resources

ADGS ROG.doc

Case Study: Optimal track spacing for AGDS for small scale surveys ENV CS10 Optimal track spacing for AGDS.pdf.

Case Study: Optimal detection and identification of biogenic structures using side scan sonar: ENV CS01 SSS ID Biogenic StructuresEd.pdf.

Links to websites

http://www.questertangent.com/pdfs/QTC_Impact_04_Hi.pdf

Swathe systems

There are two types of swath systems, which use slightly different applications of sound wave technology. **Multibeam echosounders** principally operate in the same way as single beam echosounders, but comprise of a large number of emitting and receiving transducers positioned in such a way as to fan out the emitting sound pulses on either side of the boat, so creating a swath of coverage. The width of this swath is often in the order of seven times the depth of water in which they are operated. The strength of the returning signals is mapped to show the seafloor "backscatter", an indication of the hardness and roughness of the seafloor.

Presently multibeam echosounders are used extensively for hydrographic charting of the seafloor for the production of navigation charts. They also provide a key tool for habitat mapping owing to the large coverage they can achieve and the use of backscatter information to help determine seafloor characteristics. For details of backscatter analysis and research refer to the MESH Backscatter workshop report (Backscatter_Workshop_30-31_March_report v2 _WEB_.pdf).

Interferometric systems emit energy from a single point and detect the returning signal at two points, one mounted above the other. These continually measure the "phase difference" of the returning signal (MESH_Standards_&_Protocols_2nd Edition_26-2-07.pdf). In this way interferometric systems produce a swath of coverage of the seafloor, up to 15 times the water depth. Interferometric devices tend to be mounted on the supporting vessels hull or pole mounted over the side. The difference in phase of the returning signal (as measured by at the two points) is used to calculate and chart depth, while the strength of the returning signal is used to produce "sidescan sonar like" images (see section Sidescan sonar), which tend to be of greater resolution than the comparable backscatter images from multibeam systems. While this combination of bathymetric measurement and high resolution imagery is an inherit advantage, their application is not presently mainstream owing to processing complexity. Promising results have been produced however, and their application is growing.

Links to other sections

Sidescan sonar

Links to resources

Backscatter_Workshop_30-31_March_report v2 _WEB_.pdf

MESH_Standards_&_Protocols_2nd Edition_26-2-07.pdf

Swath Bathymetry ROG.doc

Case study – Hemptons Turbot Bank

Links to resources

Survey Data Analysis Investigation for Hemptons Turbot Bank.doc

Sidescan sonar

Sidescan sonars tend to take the form of towed devices, being lowered in to the water column behind the supporting vessel by cable. This "tow fish" emits a beam of energy which sweeps the seafloor perpendicular to the vessels course. Lowering the device into the water effectively gets it closer to the seafloor, enabling increased detail of the returned data and reducing wave interference from the vessel. In deepwater, it is necessary to accurately position the tow fish by using ultra short baseline technology.

Links to resources

Sidescan sonar ROG.doc

Sidescan Sonar Case Study

Sidescan Sonar Case Study.doc

There is still a lot of development taking place in the technology of echosounders, the ways in which returning signals are effectively decrypted and the analysis of the resulting maps. These tools are extremely valuable for habitat mapping, enabling the production of complete coverage maps detailing water depth, seafloor structures and inferences to characteristic roughness and hardness. The information presented here is based upon current understanding and experience. This is however a developing science. As the application of swath and single beam instruments tends to be driven by their use in the field of hydrography, the acceptable standards for hydrographic surveys are recommended as a place to begin. For a simple description of these see Mills (1998), for more detail refer to the MESH_Standards_&_Protocols_2nd Edition_26-2-07.pdf (Coggan *et al.* 2007).

Links to resources

Sidescan Sonar Case Study.doc

Case Study Sidescan-sonar exploration of (sub)littoral oysters and mussels: WE_TNO_SSS_oysters_mussels.doc.

MESH_Standards_&_Protocols_2nd Edition_26-2-07.pdf

Sub bottom profilers

There is a large range of sub bottom profiling devices which, as the name suggests, are designed to look below the seafloor at structural geology and sedimentation patterns. They have received a lot of development owing to their use in the hydrocarbon industry for mapping oil and gas deposits below the seafloor. They can be divided on the basis of the wavelengths and strengths of the emitted sound into "sparkers", "chirps", "pingers", "boomers" and "air guns".

Sub bottom profilers can be either towed behind the supporting vessel, hull or pole mounted, and provide a straight line look through the seafloor, much like slicing through a layered cake. By towing an array of sound–emitting devices with listening or receiving "hydrophones" behind a vessel, three dimensional maps can be produced. This approach tends to be the realm of the hydrocarbon industry, proving extremely expensive. For habitat mapping only information on surficial sediments (usually to less than 50cm depth) tends to be required, unless the sediment is highly mobile, or an insight into historical development is desired. This may, for example, relate to knowing the depth of the interface between a sand wave field and the more stable layer of clay, mud or bedrock below, and having an indication of frequency (usually in the order of months or years) over which this basal layer becomes exposed – so giving rise to a change in the seabed material and hence habitat.

Links to resources

Sub bottom Profiling (Chirp) ROG.doc

3-D seismic imagery

Links to resources

3D seismic imagery ROG.doc

Benthic sampling techniques

Benthic sampling techniques are essential in habitat mapping studies since they provide the "truth" data on the actual composition of the seafloor. While they are commonly used in conjunction with either a remote sensing or an acoustic technique, in which case they are used to "ground truth" seafloor classifications, if they are collected in high enough densities over survey areas they can be used to establish distributions and define habitats. "Point samples", if taken on regular occasions form the basis for monitoring purposes – for anthropogenic impacts and change in seabed composition over time.

Samples commonly provide two categories of information: a sample of the seafloor material that can be analysed in terms of its structure – a physical sample – is often taken for geological analysis and; a sample providing a collection of the species living on or in the seafloor, these can be identified and counted to give detail of the biological assemblage present at a point – a biological sample. Biological and geological/physical samples should, in the main, be taken separately from different grabs; however the practice of separating out a portion of a biological sample for geological analysis is been followed by some groups. This should not be done as quantifiable results cannot be achieved for either the biological or geological sample.s Commonly, for biological sampling to give quantifiable information, replication of the samples is essential, so adding to the number of samples that need to be collected.

An example photograph of a benthic grab sample from a cobble/ pebble substratum (note the rule giving indication of scale).

There is a range of sampling devices commonly in use for benthic sampling, each designed to provide a certain type of sample over a specific ground type. Grabs and corers are commonly used for both geological and biological sampling in softer, unconsolidated sediments while trawls and dredges provide only biological samples.

Commonly-used grabs include Shippek, Hammon, Van Veen and Day. There are also a range of corers available for sampling. Each has advantages and disadvantages depending upon the seafloor material, the type of sample required and its volume. The size of the sampling device will define the size of vessel needed to deploy it (or vice versa) and the number of people necessary to do so. For representative particle size analysis, greater volumes are required from gravel rich sediments than for muds.

Key to the choice of sampling device will be the targeted type of sample: geological or biological for infauna (animals living within the substratum) or epifauna (animals living on top of the substratum) and a prior knowledge or suspicion of the seafloor material. **Trawls and dredges should not be used on fragile habitats owing to their destructive nature.**

Grabs obtain a disturbed sample of the seafloor. To collect an undisturbed sample, a coring device is needed. These give information on the variation of material below the seabed and the depth of biological activity. Such devices include box corers, megacorers, gravity corers and vibrocorers. The depth of penetration depends on equipment type and the nature of the seabed material

Grab sampling

A comprehensive review of the variety of commonly used grab sampling devices and their operation is presented in the Review of Standards and Protocols (MESH_Standards_&_Protocols_2nd_Edition_26-2-07.pdf). Their broad application makes defining a single ROG difficult and the reader is referred to this report with consideration given to:

- The sediment types to be sampled,
- The available time and resources for sample collection and processing,
- Methods used in previous surveys of the same or adjoining area(s) intending to be integrated,
- The intended use of the data.

Grabs can provide quantitative samples of benthic fauna.

Links to resources

Case Study Outer Bristol Channel Marine Habitat Study. MESHcaseOBCMHS.doc

Case Study Macrofaunal assemblages and their sedimentary habitats: Working toward a better understanding. 6.19 MESH PERIOD 3 Activity NMGW - Irish Sea Forum Paper.pdf.

MESH_Standards_&_Protocols_2nd Edition_26-2-07.pdf

Box coring

Links to resources

Box_Coring_ROG.doc

Trawls and dredges

Links to resources

Trawls and Dredges ROG.doc

Intertidal surveying

Surveying of intertidal areas – commonly beaches and estuaries usually takes the form of foot surveys, where the operator will be furnished with a mobile GPS, field survey log books or handheld digitising database and reference keys. The field surveyor will usually walk in a predefined survey pattern, recording sediment types and species along the route. Samples may be collected and photographs taken for subjective and/or objective appraisal. The case study of Glenan Archipelago (Glenan Archipelago Case Study.pdf) shows integration of intertidal survey approaches. Intertidal foot surveys often comprise the ground-truthing component of remote sensing survey techniques (see Remote sensing techniques).

A cobble/ gravel beach area (in Galway Bay, Ireland) at low tide – a typical intertidal area suitable for surveying by foot.

Links to other sections

[Remote sensing techniques]

Links to resources

[Glenan Archipelago Case Study.pdf]

Subtidal surveying using divers

Self Contained Underwater Breathing Apparatus (SCUBA) diver surveys are conducted in numerous ways, usually between depths of 5m and 30m. Dives below 30m begin to introduce decompression obligations, increasing the health and safety requirements of diving operations. Decompression obligations of 20 minutes or more, irrespective of depth, require a decompression chamber to be on site. In UK and Irish waters divers are required to hold diving qualifications issued by the UK Health and Safety Executive (HSE) or an advanced level of recreational qualification for scientific diving, for instance the British Sub-Aqua Club (BS-AC) Advanced Diver qualification, equivalent in standard to [CMAS Three Star Diver] (http://www.hse.gov.uk/diving/qualifications/sci.htm).

Close

Diving surveys can be conducted in numerous ways, for example quantitative quadrant counts of target species at regular intervals along a transect, or qualitative survey transects noting presence of species, and following the edge/ interface between two habitats – for instance following the edge of sea grass (*Zostera*) beds with the diver trailing a surface marker buoy indicating position to the support boat for fixing. Divers can be used to collect core samples of sediments, make detailed species list and collect both qualitative and quantitative photographs and video transects.

A close up "macro" photograph of an anemone taken by diver.

Owing to the large range of applications of SCUBA diving to seafloor habitat mapping and regulations controlling the activity for scientific and commercial application, no one method is specifically recommended. Readers are directed to the MESH_Standards_&_Protocols_2nd_Edition_26-2-07.pdf (Coggan *et al.,* 2007) for survey descriptions, the HSE for necessary qualifications and training (http://www.hse.gov.uk/diving/index.htm) and the U.S. National Oceanic and Atmospheric Administrations dive section (http://www.dive.noaa.gov) for further advice.

Links to resources

MESH_Standards_&_Protocols_2nd_Edition_26-2-07.pdf

Links to websites

http://www.hse.gov.uk/diving/qualifications/sci.htm

http://www.hse.gov.uk/diving/index.htm

http://www.dive.noaa.gov

Techniques for physical samples and geotechnical measurements

The geological analysis of sediments can reveal much about the nature of the seafloor. A simple description may be enough to align a sample to a habitat classification system such as EUNIS – "Circalittoral muddy sand" or "Circalittoral mixed sediments" for instance. More detailed descriptions can be gained by analysing the particle sizes in a sample and their relative proportions to one another, the shape of these particles, information on the compactness of the sediment and the size of gaps between the particles, and of course the material they are made of – metamorphic, sedimentary, biogenic – it's origin and age. These details begin to reveal not only the history of an area of seabed but also how areas relate to one another. The reader is referred to the Geological Society of London for further information

(http://www.geolsoc.org.uk/template.cfm?name=geohome).

Links to websites

http://www.geolsoc.org.uk/template.cfm?name=geohome

Geotechnical measurements

Standards and protocols for the various geotechnical test measurements and observations are clearly defined within the section on Geotechnical Measurements in the MESH_Standards_&_Protocols_2nd_Edition_26-2-07.pdf (Coggan *et al.,* 2007). It is strongly recommended that guidelines, as defined and published by the BS (responsible for British Standards), the International Organisation for Standardization (ISO) or the American Society for Testing and Materials are comprehensively followed. These organisations can be accessed *via* the following links and the required standards and operating protocols may be purchased and downloaded on line. It is recommended that each is assessed to identify the most appropriate for a study:

- British Standards Online: http://www.bsonline.bsi-global.com/server/index.jsp
- International Organisation for Standardization - http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=19255
- American Society for Testing and Materials:- http://www.astm.org/cgi-bin/SoftCart.exe/NEWSITE_JAVASCRIPT/DOMnewstandards.shtml?L+mystore+qguf6791+1169734372

For details of recognised geotechnical standards refer to the geotechnical measurements and standards

Links to resources

Reference to Geotechnical Measurements and Standards.doc

Underwater video and imaging techniques

Underwater video and imaging techniques include both photographic (also known as “stills”) and video cameras. These may be mounted on drop frames, sledges and Remotely Operated Vehicles (ROVs) (**Error! Reference source not found.**). These techniques have become an integral part of seabed surveying and habitat mapping studies, particularly for ground truthing of acoustic surveys. Operationally, sledges are towed behind a support vessel, drop frames lowered over the side and the vessel drifts or steams very slowly (<1knot) and ROVs are lowered over the side while the vessel either sits at anchor or on a fixed position using a dynamic positioning navigation system. There is a large array of literature describing use of video and cameras for habitat mapping; these are detailed in the MESH_Standards_&_Protocols_2nd_Edition_26-2-07.pdf (Coggan *et al*., 2007); Video_Working_Grp_Report_Draft_24-April-2007.doc (White *et al*., 2007) and; the MESH Video ROG.

A digital photograph taken from a Sea Tiger ROV.

Links to resources

Video ROG v11.doc

MESH_Standards_&_Protocols_2nd Edition_26-2-07.pdf

Video_Working_Grp_Report_Draft_24-April-2007.doc

Using techniques in combination

Most habitat surveys make use of several surveying techniques in combination to provide complimentary information of the same area. These might be operated concurrently, for instance sub bottom profiling and seafloor acoustic discrimination techniques, or may be used at separate intervals, grab sampling and video camera tows for example. Other complimentary techniques may be used in surveys undertaken at greater time intervals from one another, for instance a shoreline aerial photometric survey and a ground truthing foot survey.

The requirements for using techniques in combination fall into a number of categories – to provide data sets that measure different variables for the same area to aid habitat discrimination and mapping; to provide "ground truthing" information for other, remotely used techniques and; to provide focused, detailed information of a smaller sub-zone of the survey area in order to investigate specific facets or activities and/ or to enable extrapolation to other areas. For instance investigations into variations in distribution patterns over a range of spatial scales comprising intensive replicate sampling at the local scale (10s of metres) and regional scale (1000s of metres). Additionally combinations may arise through collaborative interest surveys – a magnetometer may be used for geophysical purposes in a combined geological/ habitat mapping survey with echosounders.

Possible interference between surveying techniques must be considered. This may take the form of direct interference, for instance the sound waves emitted by certain acoustic systems interfere with one another causing noise blankets in the data sets. Additionally, incorrect deployment of sound-emitting systems can cause interference as the sound bounces off either the bottom of the vessel or the other towed body. As a rule parallel use of systems operating at similar frequencies should be avoided, unless an alternate trigger system can be used.

Indirect sources of interference and incompatibilities among techniques also need consideration in the planning stages of a survey. These often take the form of logistical usage. Obviously some techniques cannot be used concurrently – grabs will not be possible while video tows are being made or sidescan sonar tow fish cannot be used at the same time as towed video cameras. Examples of operational interference/incompatibilities include the time costs of grab sampling in deep water while an acoustic survey is being undertaken – relevant if for instance the survey has a strong hydrographic component as intensive sampling will slow the survey pace down so reducing coverage.

Airborne sensors

Airborne sensors are rarely used independently. The reasons for this tend to be based on cost. The cost of the platform (aeroplane or helicopter) tends to be high relative to the cost of sensor rental, making it financially advisable to get the maximum return on any sortie. Georeferenced photographic (visible light) survey results are invaluable for interpretation, analysis and location of other data sources and so, are almost always provided with other sensor types. This is the case for aerial photography, electro-optical techniques, multi-spectral and LiDAR.

Airborne techniques are usually accompanied by ground surveys to "truth" the remotely sensed data. Ground truthing surveys often take the form of foot and/or small boat surveys of intertidal and shallow water areas, incorporating logging of distributions of material (sediment), fauna and flora, photography and return to the lab of sediment and biological samples for further processing and identification. Worthy of specific mention is the recent development of LiDAR and processing of the strength of the returning signal which penetrates the water column and reflects off the seafloor – akin to multibeam backscatter, this potentially provides information of seafloor roughness and density.

Readers are referred to the Airborne Digital Imagery ROG, LiDAR ROG and Aerial Photography ROG which deal with the main aircraft-deployed (planes, helicopters) electro-optical data acquisition techniques used to help in the fine scale physical characterisation of the intertidal and seafloor. Planning considerations are also dealt with within these ROGs:

Links to resources

Aerialphotography ROG.doc

Airborne digital imagery ROG.doc

Satellite Imagery ROG.doc

Acoustic techniques

In practice, acoustic techniques are rarely used in isolation for habitat mapping as ground truthing is essential in calibrating returned signals. There are exceptions to this: bathymetric data used to create Digital Elevation Models (DEMs), or Digital Terrain Model (DTMs), which can in turn be used with mathematical and GIS tools such as the Benthic Terrain Modeller (http://www.csc.noaa.gov/products/btm/) to create classifications of Bathymetric Position Indices; backscatter data may provide "unsupervised" classifications of the seafloor and; sidescan sonar coverage may likewise be used to demark areas with differing characteristics (See *How do I make a map?*). In contemporary habitat mapping surveys, acoustic systems tend to be optimised with greater relevance to backscatter data and it is very rare for an acoustic technique to be used without an accompanying ground truthing sampling campaign or independent of other sounding devices.

Ground truthing is a critical part of a dedicated habitat mapping survey when acoustic systems are being used. Such ground truthing can take the form of trawls or dredges, but more often is provided by grab samples, video tows or drop frames and stills cameras, or a combination of imaging and grab sampling techniques. These then provide evidence of the composition of the seafloor, which can then be translated back to the acoustic bathymetry and acoustic "fingerprint" charts.

The use of multiple acoustic techniques is also common. Single beam devices are often used in parallel with swath devices and sidescan sonars are often towed behind vessels recording multibeam data; enabling sidescan imagery to be "draped" over multibeam DEMs. Surveying with parallel techniques are used to correlate instruments, for instance depths from a single beam echosounder can confirm the measures recorded by multibeam. Single beam data may be passed through an AGDS, giving proxy information on the nature of the seafloor – this can be used both to correlate multibeam backscatter classification and as a complimentary data set.

Issues with using more than one acoustic system at a time do arise. As well as the obvious physical interference of multiple towed devices, acoustic interference is an important consideration when using more than one system. In certain situations the emitted sound pulses of towed and/or hull mounted systems can cause interference on one or both systems. This is dependent upon the frequency the systems operate on, the mounting locations of the transceivers in relation to one another and water depth. In certain instances it may be necessary to turn one of the instruments off or adjust firing intervals to ensure that the collected data are noise free. Such mismatches can be avoided through consideration of operating frequencies and mounting positions.

Links to other sections

How do I make a map?

Links to resources

Case Study Use of complementary techniques for habitat mapping: [ENV CS13 Complementary acoustic survey techniques.pdf].

Case Study Appropriate use of multi-beam and AGDS: [ENV CS12 Appropriate use of multi-beam vs AGDS.pdf].

Case Study Seafloor habitat survey of an area of iceberg plough marks off the north west coast of Ireland. [IceBergPlough_Report_II.pdf].

Case Study Greencastle codling bank – Analysis of multibeam backscatter and ground truthing in relation to demersal fishing catches. [Greencastle Codling Bank Case study for MESH_181006.pdf].

Links to websites

http://www.csc.noaa.gov/products/btm/

Other common combinations of techniques

Many other combinations of techniques besides acoustic and remote sensing with ground truthing have been and are commonly in use. Techniques that are frequently used together are briefly discussed at the start of *How do I collect my data?*. To detail these further and list others, common examples include:

- Stills cameras with video – this provides images of higher resolution, useful in identifying fauna and flora (see *Underwater video and imaging techniques*).
- Stills and or video camera mounted on grab samples or box corer – useful in obtaining a sample of seafloor material with an accompanying image putting the grab/core sample in context with the surrounding seafloor material and its structure.
- Stills and or video camera mounted on the front of a trawl or dredge – as above, useful in obtaining faunal samples with imagery to put them in context with the surrounding seafloor. This option is not often used owing to the relatively delicate nature of cameras and high impact rates dredges and trawls experience with the seafloor.
- Foot survey field recording, collection of physical samples and photographs.
- Shallow dive survey combined with diver video and stills photography, and accompanying ROV mounted video and stills (or drop frame) which can then progress to deeper areas.

Survey data: organisation and metadata requirements

Habitat mapping surveys generate very large volumes of data which need careful organisation and management. Additionally, surveys typically employ multiple techniques and surveyors, adding to the complexity of tracking what data has been collected, how, when, by whom and how it all interrelates. Once a survey programme has been completed, the data may be passed to other people or organisations for processing, analysis and storage. It is important that key information is recorded at the time of the survey, in a structured manner so that over time and when passing the data on to others its subsequent processing and interpretation is not hampered be gaps in survey detail. It is not good enough to rely on the memory of individuals as to how each piece of data was collected!

There are three main aspects to consider:

- How should the survey data be organised?
  Management of multiple techniques, people, places, dates and samples so that their relationship to each other is properly documented. It is not much use taking a photograph of a grab sample if, at a later date, you cannot remember which photograph relates to which sample.
- What information should be recorded?
  Recorded metadata need to ensure that future users of the data know how it was collected, when, by whom, to what standards and how it has been processed or manipulated. This is vital information about the provenance of the data that allows its users to know what it is suitable for (or more importantly what it is not suitable for). Consideration needs to be given to use of the data beyond the scope of the study, in national and international data archives. Was a multibeam dataset collected to international hydrographic standards to enable its use for navigational charts? Can I integrate grab sample datasets without knowing what sieve size was used?
- How should the data be stored?
  Using an appropriate medium to store the data and ensuring it is correctly labelled will ensure they are readily usable in the future, will not deteriorate over time and may be easily integrated with similar data from other sources. Data without proper labelling (showing when and where they were collected) are expensive data that have little or no value in the future.

MESH Guide provides advice on general issues relating to survey data management, offering a structure for organising data during a survey and provides recommended metadata fields for each type of technique employed.

Organisation of survey data

The organisation and management of a survey is vital to its success. Integral to this is proper management of the different survey techniques and their data, so that the survey concludes with a series of datasets which are properly documented. The survey collection phase is a costly part of the overall mapping process and one which cannot often be readily repeated; poor documentation can render the data useless.

Not only must the survey leader (also known as Chief Scientist or Party Chief) finish the survey with a set of well documented individual data sets, but the relationship of the datasets to each other must also be known. Key questions that should be answered are:

- How many samples were taken?
- Which techniques were deployed at each site?
- Was there a photograph taken of each grab sample?
- What numbering or labelling system was used to identify where data came from?

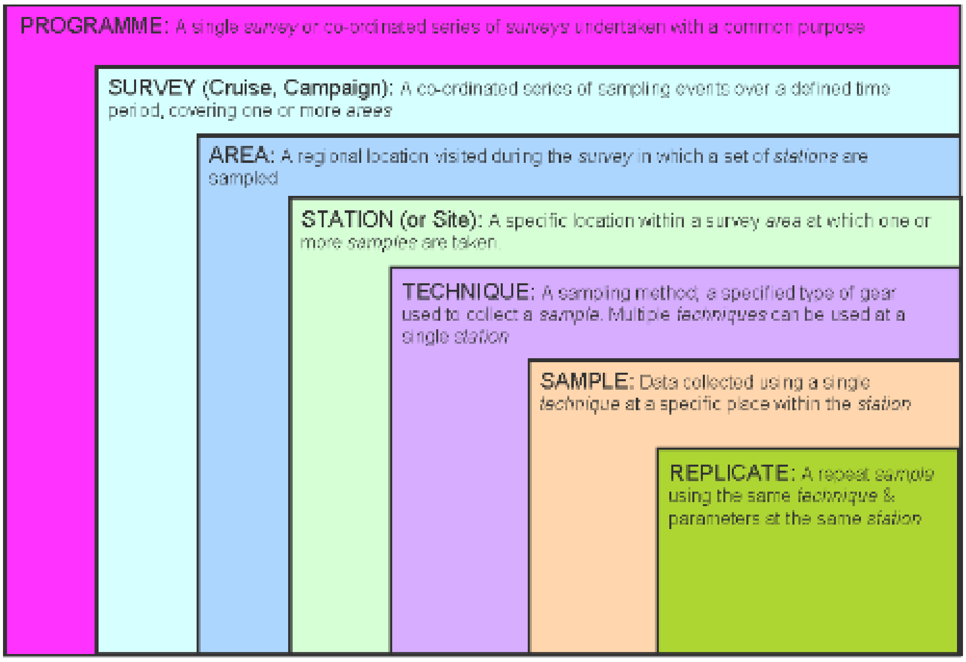
There are many ways in which the overall organisation of survey data can be achieved; often an Institute or survey group will develop its own particular practices suited to the types of survey they undertake, the environments they work in and the ways in which data are managed in-house (*e.g*. corporate data management systems). While every survey is to some extent different and each technique differs in how it maybe operated, there are many common threads both to the process of data collection and to the data itself.

The process of a survey, from its organisation, arriving on site, deploying survey instruments/techniques, collecting samples and compiling data sets has much in common from survey to survey and technique to technique. A common structure is described in the section ‘A MESH model for structuring survey data’.

Information concerning the where, when, how, who, why and what was undertaken (metadata) has an equally high level of commonality both among the techniques on a single survey and among different surveys. The later section on ‘Metadata – vital information about the data’ describes the metadata recording requirements proposed by the MESH Project.

A MESH model for structuring survey data

All surveys tend to follow a similar pattern: they have a defined geographical area to be surveyed, which may be sub-divided into a series of smaller areas for convenience, over a particular time period or periods. For any sampling event, there is a recognised hierarchy of data and metadata (information or data about data) (illustrated in the Figure below), which if followed will make its organisation intuitive. Information relevant to the first five levels of this hierarchy (*Programme* through to *Technique*) will be known prior to the sample being taken, as they relate to the planning stage of the survey.



Hierarchical structure of sample site data organisation.

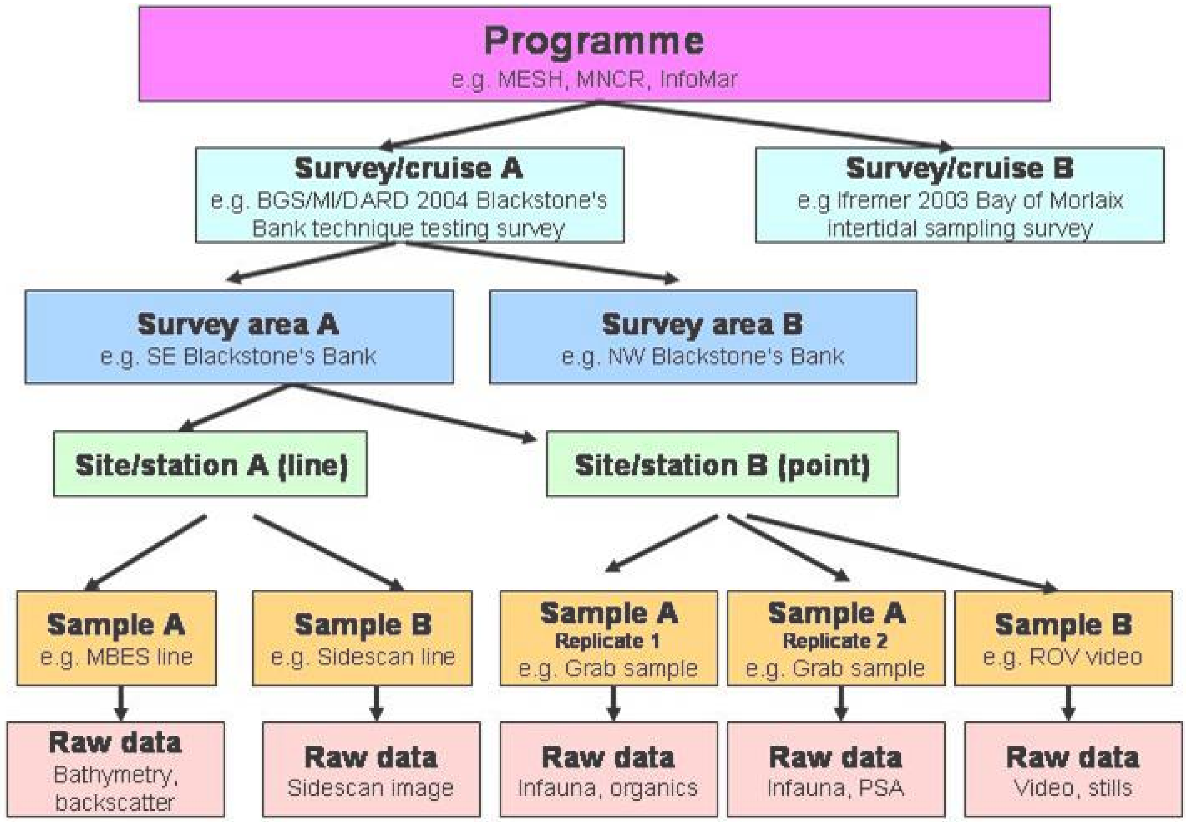
Surveys are conducted by visiting sites within a defined survey area each day and deploying a number of techniques, sometimes several times. These yield the data or samples, with some techniques producing more than one type of data (*e.g.* multibeam gives backscatter and bathymetric data; benthic grabs may give biological and geological samples).

This general concept of a survey has been used to develop a common structure or model for habitat mapping surveys and documentation needed to accompany the data yielded. This model is widely applicable for all types of survey and monitoring programmes in the marine environment, as well as all types of survey techniques. Details of the terms used (as shown in figure below and alternative names are listed in the following table). A description/ purpose is given for each level in the structure. The levels are used to help organise the way data and metadata are collected, labelled and inter-related for each technique employed and all data and samples collected during the survey.

Terms used in the MESH survey organisation model.

Term	Alternative term	Description
Programme	Campaign, project	Composed of a series of surveys undertaken with a common purpose, occasionally over a period of many years
Survey	Cruise	Implemented within a programme or as a one-off event. Undertaken by a set of surveyors over a defined (usually continuous) period and usually in a single general location and for a single overall purpose
[Survey] area	Location	Geographically-defined place/location visited during the survey in which a set of stations are sampled or tracks traversed
Station	Site, event	Place visited within a survey area at which one or more samples (single or multiple techniques) or images are taken
Technique	Method	Details of the device used to collect the data or samples (note that this level of metadata does not pertain to the

Term	Alternative term	Description
		sample location and so does not necessarily relate to survey data organisation.
Sample	Record	Data collected using a single technique at a specific place or habitat within the site/station
Replicate	Sample	Repeat sample using same technique & parameters at the same place



MESH survey data organisation model.

Metadata – vital information about the data

During the compilation of the MESH WebGIS, it became apparent that many of the historical reports had missing or inaccurate information and therefore the data could not be used or were of limited use. This is despite the fact that the work was probably undertaken utilising standard methodologies by experienced marine habitat mappers. Recording of metadata ("data about data") has become absolutely necessary to allow full use of any survey data set, digital or analogue. This is being compounded by the increasing volumes of data acquired; the development of Internet distributed and displayed data and on-line data archives.

Metadata describe the source, content and quality of data and it is through the evaluation of metadata that a user can determine if it meets the needs of their intended application. At a very basic level, metadata includes spatial and non-spatial information, for example, who collected the data, who distributes the data, where they were collected, when, how and why they were collected. Caveats such as how the data should be used can also be included in the metadata fields.

The recording of metadata for each data set is perhaps the most neglected aspect of surveys. Yet such information grows in importance over time as vital details about how data were collected become lost in people's memories. This can subsequently make interpretation of data difficult if critical information about it is missing. Such information is also important in assessing the overall quality of any maps which are derived from a survey (see *How good is my map?*). It is also important for such information to accompany the data when it is archived, passed to third parties or is incorporated with other (corporate, national and international) data sets and data bases.

Recording metadata in a consistent way greatly facilitates the sharing of data. As contributions to databases increase they need to have common formats and standardised metadata. A reliable approach is to ensure metadata are compliant with the ISO standard 19115, to which most contemporary marine spatial and temporal metadata records now conform.

Survey metadata serves the following functions:

- It describes the data set (what it is, who collected it, why, where, how and when), so that it can be properly interpreted in the habitat map-making process (helping to avoid its misinterpretation),
- It provides information that can be used to assess the quality of the data and any interpreted products (such as habitat maps) (see *How good is my map?*),
- It provides summary information that can be used in discovery metadata catalogues, allowing others to find the data (see *What can I do with my map?*),
- It facilitates the proper archiving of the data, its distribution to third parties and its contribution to other databases by describing the provenance of the data set, enabling others to reuse the data within suitable limitations.
- In considering the survey model described in the earlier section 'A MESH model for structuring survey data' it follows that there will be some information (metadata) that can be ascribed to each level in the survey model. The information is more general at the higher levels (programme, survey) and becomes increasingly more specific to a particular technique and dataset at lower levels (sample, replicate).

Links to other sections

A MESH model for structuring survey data

How good is my map?

What can I do with my map?

Survey metadata – recommended standards

A standard set of metadata fields has been developed for habitat mapping studies. The standard covers fields for Programme, Survey, Area, Station, Sample and Replicate levels (Metadata fields.doc). This standard set has been derived by using the survey data model as described in the section ' A MESH model for structuring survey data' and comparing the metadata fields from similar databases, the information available in the MESH_Standards_&_Protocols_2nd Edition_26-2-07.pdf (Coggan *et al.,* 2007) and from the MESH Recommended Operating Guidelines.

The fields collectively will provide sufficient metadata documentation to:

- Derive a discovery metadata entry for the MESH metadata catalogue and other metadata portals,
- Provide sufficient metadata to describe the origins and quality of each dataset and allow the user to understand any limitations it might have,
- Provide metadata which will enable an assessment of confidence in the habitat map to be made,
- Support the submission of the datasets to national data archives.

Fields related to each technique are listed, together with fields for data processing and storage, in the associated spreadsheet (Video metadata v4.xls). The spreadsheet provides additional details on:

- The required format for each field (text, number, term list),
- Whether the field is mandatory or optional
- The term lists to be used
- Example data entries for each field
- The correspondence of the fields to those in other databases.

From the listed set of metadata fields (Metadata fields.doc), additional fields required on metadata for each technique, the data processing and storage, it may initially appear a complex and burdensome set of data to record. In practice, a significant number of fields are optional and not relevant to all surveys and the use of "multiple term" lists significantly reduces the effort required to complete the metadata entries during a survey.

MESH is developing a database application to record the above metadata system, which aims to provide a comprehensive data capture application for use during the survey and in the post-survey processing phase. Through the cascading of data from higher levels to lower levels and the automated completion of some fields it is expected to make the database relatively quick and simple to use.

Links to other sections

A MESH model for structuring survey data

Recommended Operating Guidelines for habitat mapping

Links to resources

Metadata fields.doc

MESH_Standards_&_Protocols_2nd Edition_26-2-07.pdf

Video metadata v4.xls

Data cleaning and basic processing

All sampling and surveying techniques require monitoring during operation to ensure they are performing correctly and the resulting samples or data are reliable. This may be achieved by correctly recording metadata, which can act in many cases as a check list to ensure data are properly recorded. Once collected, certain levels of processing, cleaning and storing will need to be undertaken before the data are in a suitable state for the analysis phase (*How do I make a map?*). This initial processing will check that data are correct – and provide a true record of the variable they were intended to record, positioned in the right place at the right time. At the end of this stage, a clean 'raw' data set should exist, which is suitable for archiving and to be passed to the next phase of analysis, whether this be for deriving a habitat map or another purpose for which the data are also appropriate.

Links to other sections

How do I make a map?

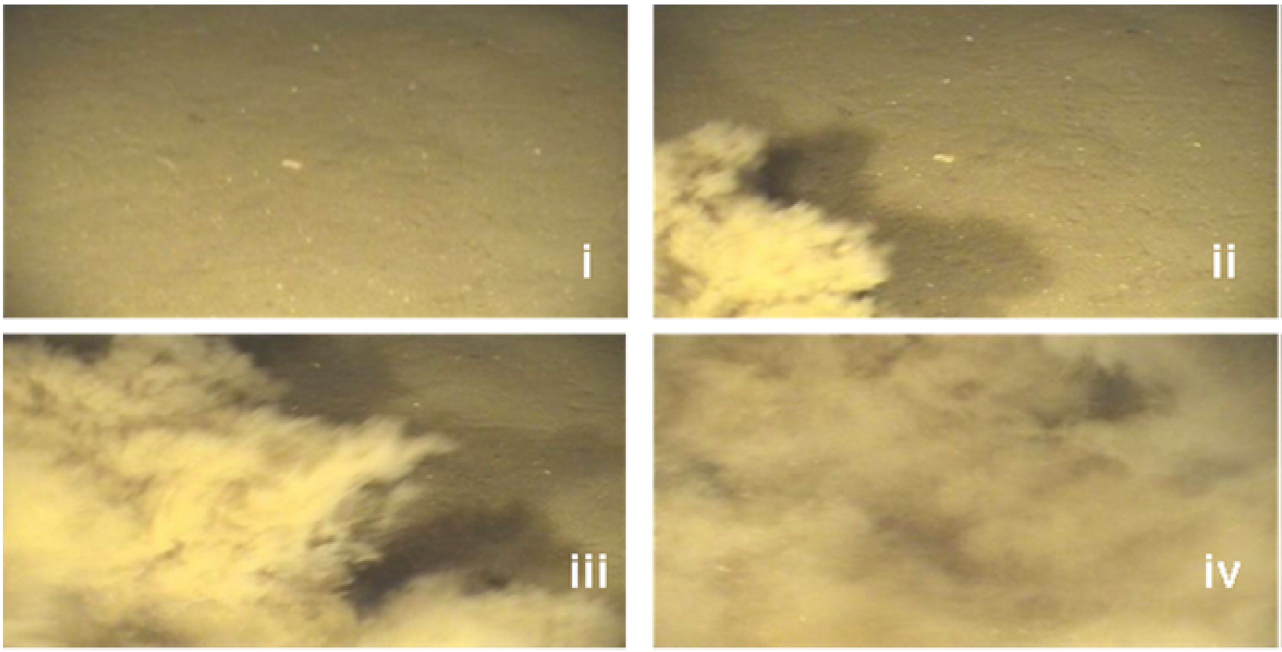
Data cleaning

Data cleaning primarily involves the removing errors or "outliers". For instance in multibeam acoustic data, echoes will, naturally, owing to reflection and refraction and other sources of noise, fall outside an accepted range of accompanying soundings. All data sets will incorporate outliers. In some instances these will need to be retained or dealt with in special ways; for instance rare species in biological data sets can complicate multivariate analyses and so may need to be removed for a particular analysis, but as they are not 'wrong' data they must be retained in the definitive copy of the data set.

The position of grab samples should be recorded at the moment the grab hits the seafloor during collection and this then routinely double checked. Positioning of towed items can be achieved in two ways:

- Through accurate positioning using a positioning beacon, a USBL (Ultra Short baseline) system for instance attached to the sledge or cage. The resulting positioning data from this can be fed directly into the recording device, so positions and images are simultaneously recorded or linked post collection, using time as the common denominator.
- Alternatively the position of a towed instrument can be estimations by calculating "layback" using Pythagoras' theorem or catenary curve formulae, which takes into account curvature of the tow line. These are generally applied post collection and while their estimation of distance behind the towing vessel may be considered a reasonable estimation, they do not consider an instruments true position in relation to the position of the ship owing to cross tides or currents. In the case of any post data collection positioning, the positional information will need to be checked by an operator against all available information pertaining to position. For video footage this could include acoustic backscatter charts showing strong demarcation between areas and checking the location of the camera relative to these when video footage shows a marked change in seafloor composition.

Data cleaning can take other forms. In the case of video footage certain elements of a camera tow or "run" will not be useable; the very start of a camera run for instance should not be included in the analysis. Cameras are invariably turned on while they are on their way down through the water column so that the operator knows when they have reached the seafloor. Once they are down a short "settling period" should be allowed so the camera can drift away from its landing zone where it is bound to have disturbed the seafloor and the silt will obscure the camera field of view. Other examples will include points along a video survey line where sediment has been disturbed by the camera frame. Clearly such instances will not contribute to the analysis – if only because they reveal nothing of the seafloor other than there is loose sediment!



A series of stills taken from video footage showing the reduction in visibility, and hence useful footage, arising from fine sediment disturbed by the video frame. (Stills i. through iv. are taken at approximately 0.3 second intervals).

Positional corrections

Positional corrections can include transformations between different geodetic projections. The recognised standard datum for mapping is WGS84 (World Geodetic System 1984).

Projections may be changed automatically, for instance within a GIS environment. Alternatively if data are held in a spreadsheet they may be changed using a desktop PC application or web hosted co-ordinate converter.

Positional transformations can also incorporate corrections of any human error, in recording or digitising, for instance grab sample locations. Some may be obvious: positioned over land, where a value may be an obvious factor larger or smaller that it should. Such errors are often easily rectifiable through comparison with others in the data set, though if numerous this process can be time consuming. It should be noted that human errors are inevitable when large number or records are being written, typed or transposed manually.

Tidal height corrections

Tidal height corrections are necessary when using single beam, swath or LiDAR techniques to determine bathymetry. Internationally recognised standards for hydrographic surveys (see ROG on Swath surveying – Swath Bathymetry ROG.doc) detail the necessary accuracy of these corrections, which will need to incorporate a network of tidal gauges and/or predictive tidal models.

Links to resources

Swath Bathymetry ROG.doc

Acoustic techniques

The primary cleaning and processing tasks, post collection, of data from acoustic techniques involves removing outliers (erroneous and stray "pings") and applying tidal corrections. For multibeam surveys for instance, outliers or errors, show up as erroneous points above and below the primary cluster of points (seafloor) and can be selected and removed. Tidal corrections require the application of modelled or measured tidal changes in the survey area over the period it was surveyed. These can be measured with tide gauges or estimated using tidal models (*e.g.* from published hydrographic tidal information).

Critical to acoustic survey techniques, with the initial calibrations is maintaining the correct equipment settings and inserting the required corrections. If this is not monitored it will prove difficult to remove post survey (reference to the Acoustic ROG – Swath Bathymetry ROG.doc – and manufacturers manuals are recommended). Accurate positioning of the vessel is critical, with regular measurements of the velocity of sound through the water column and the motion of the vessel (heave, pitch and roll) must also be monitored. If these factors are controlled during acquisition, the post survey cleaning and processing will be much more efficient.

In summary, it is good practice to carry on board the necessary equipment to undertake instrument calibrations and to conduct data processing and quality controls directly after acquisition. This will enable the quality of the data to be checked while there is opportunity to re-survey.

Links to resources

Swath Bathymetry ROG.doc

Multibeam echo sounder and single beam echo sounder

In view of the high data acquisition rates and volumes involved in swath bathymetry operations, automated filtering is a prerequisite to data quality control and cleaning. The onboard surveyors will have to configure some online acceptance/rejection parameters to ensure that erroneous or spurious signals are controlled. This optimal usage of 'de-spiking' and filtering is critical and relies on the skill and experience of the online surveyor to vary the parameters, depending on many external factors.

Caution must be observed when using filters as sharp features or uncharacteristic seabed features may be rejected or smoothed. Where possible the online surveyor should be able to flag the data within the raw file and still record it thus allowing for later examination and possible reinstatement.

Benthic sampling techniques

Benthic samples do not provide 'streams' of data that require on line checking cleaning and processing as acoustic systems do. Some basic onboard processing may well be required however, before analysis can proceed.

Benthic samples will require correct position fixing and recording on collection. Their processing can be partially undertaken straight away – biological samples should be sieved and preserved shortly after they are recovered. Collection metadata usually includes sample position, time and water depth, and it is always a good idea to take notes describing a sample as soon as possible. A photograph, including the sample ID number and scale indicator, should be taken for every sample as a matter of course. These can prove very useful for later interpretation and conformation that a sample was collected in case of sample mix up or loss.

Appropriate analytical quality assurance and control should be ensured through the sample processing, to the faunal identification and counting of specimens. Taxa present in very low abundances that are deemed to be correctly identified – rare species – might be removed or retained depending upon the type of analysis that is to be performed. Outliers that are deemed to be wrong; misidentified or a contamination of a sample should obviously be removed.

Recognised taxonomic and enumeration standards should be followed. These include NMBAQC protocols (http://www.nmbaqcs.org/) and ICES Steering Group on Quality Assurance of Biological Measurements in the Northeast Atlantic (SGQAE) guidelines for sample processing.

Links to websites

http://www.nmbaqcs.org/

http://www.ices.dk/iceswork/wgdetailacme.asp?wg=SGQAE

Quality assurance of field identification, using the reference collections

The ROG for trawls and dredges recommends that, where possible, the entire sample should be returned to the laboratory for identification and enumeration/counting", however, trawls and dredges can collect large volume samples and, with limited offshore stowage space, fixative and storage buckets, this may not always be possible. It may be more appropriate to process the sample on deck, for instance using the SACFOR or DAFOR semi-quantitative enumerations (see the Case Study "Report on applicability of the SACFOR scale for recording relative abundances of colonial organisms in beam trawl samples" (Curtis & Coggan, 2007) (TG0511 Cefas03_Applying SACFOR report.pdf).

For quality assurance (QA) purposes, a reference collection should be kept for each set of sample. The collection should contain at least one example of each taxon/species (except where the identification is unequivocal – *e.g*. *Asterias rubens*). The reference collection can then be processed on return to shore to verify field identification. Some taxa are not easily separated by rapid assessment in the field (*e.g*. *Macropodia* sp., *Inachus* sp., *Ebalia* sp., *Galathea* sp., *Nucula* sp., *Abra* sp., pandalids *etc*.).

If time is not available to adequately identify/separate such taxa to species level, then the entire catch (or sub-sample) of these taxa can be placed in the survey reference collection for later identification (and weighing) onshore (Note: that the term reference collection here applies to a collection of specimens sorted while on survey for later identification in a laboratory. The term may also be applied to a selection of specimens kept in a laboratory to confirm identifications, as a library and a form of quality control, and also as a national, regional *master* collection for use in ensuring identifications are consistent at a national and international level).

Links to resources

TG0511 Cefas03_Applying SACFOR report.pdf

Sediment analysis

Geological samples must be bagged when they are collected and the sample metadata recorded. This usually includes type of device, sample position, time, water depth, the level of recovery and the type of sediment. To minimise errors and limit need for corrections, it is always a good idea to take notes describing a sample as soon as possible. These should follow a defined structure to ensure the same fields are recorded for each sample. The classification method should be considered during collection of notes so they follow similar protocols. (A summary of the BGS modified Folk Classification, aligning Folk sediment classification with EUNIS habitat classification is provided in the Seabed sediment classification Case Study (Long, 2006) (BGS_detailed explanation of seabed sediment modified.pdf). The colour of the sample should also be measured as soon as possible after recovery.

As with benthic grab samples, a photograph must also be taken, including the sample ID number and a scale indicator should always be taken. Subsampling and testing for geotechnical purposes should be conducted as soon as possible to minimise disturbance to the sediment and avoid excessive moisture loss.

Organic geochemical samples, unless otherwise directed, should be frozen. Processing and data cleaning will usually occur upon return in an adequately equipped laboratory.

Links to resources

BGS_detailed explanation of seabed sediment modified.pdf

Underwater video and photographic imaging techniques

Unlike acoustic techniques, video and photographic images do not require cleaning or correcting before interpretation. It may be necessary to incorporate interpretation rules to accommodate poor images such as those shown in **Error! Reference source not found.** (if a quantitative assessment is to be made and frames at 30 second intervals along a survey track of 20 minutes are to be analysed for biological and material content) to deal with sediment filled frames. This may state for example, that a frame with 25% or more obscured owing to dislodged sediment will be deemed unsuitable for analysis and the film will be played forward frame by frame until an acceptable frame is found, from which the next 30 second time step will be made. Images may need to be sharpened or batch processed for clarity using imaging software. This will be peculiar to each particular data set and may include increasing/decreasing brightness, contrast, sharpness and/or colour saturation to improve the details.

Video and stills images can be rendered entirely useless for mapping purposes if they cannot be adequately geo-referenced. It is therefore critical that suitable measures are taken to record positional data and to provide an estimate of its accuracy. For details of geo-referencing of video and stills footage please refer to the Video ROG (Video ROG v11.doc).

It is important to ensure that video footage is kept on secure media that will not become obsolete owing to the progress of technology. It is however, also critical that if records are to be copied to more future proof media, that the quality is ensured during the copying process. For instance some digital formats are designed to compress information, usually by averaging areas that appear similar. In the case of video footage, this will often remove detail form where it is most necessary.

Links to resources

Video ROG v11.doc

Conclusions

Producing high quality seafloor habitat maps relies on accurately collected, processed and analysed data. The concepts of map accuracy and confidence are discussed in *How good is my map?* and achieving high “scores” for both elements, following the choice of surveying technique(s), hinge upon their correct operation and accurate data recording.

There is an incredible and ever developing range of techniques for surveying seafloor habitats. The selection of technique and application for data collection should be governed by the information required and the final product maps. Methods for converting collected data into information that can be mapped are the subject of the next part of the MESH Guide: How do I make a map?. This section guides the interpretation of full coverage swath data, plotting of point and line data and where appropriate their extrapolation to cover full areas, and the integration of different data sets acquired by different techniques and analysed in different ways.

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